Ron Lee 11.1

EPA REGION X

LABORATORY

1555 ALASKAN WAY SOUTH

SEATTLE, WA

Proposal: To make predredge evaluation of sediments and to monitor trace constituents released in the Duwamish estuary by DOD dredging operation of Slip 1

Principal Investigators: J. N. Blazevich
A. Gahler

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Objective: To monitor the DOD dredging operation of Slip 1 in order to (1) evaluate the proposed hydraulic dredging of PCB polluted sediments in Slip 1 so that one may (a) estimate the amount of PCB removed by the dredging operation, (b) determine the extent of PCB translocation resulting from the dredging operation, and (c) estimate the quantity of PCB remaining on the river bottom after dredging. (2) evaluate the usefullness of methods such as the "Standard Elutriate Test" and "intersititial water monitoring" as important procedures to determine the impact of a dredging operation on dredge and disposal site water quality.

Both dredge and disposal sites will be monitored extensively for PCB, metals, nutrients, and other potentially harmful materials while the dredging operation is in progress. A pre-dredge and post-dredge pollutant monitoring program with emphasis on predictive testing and subsequent evaluation will be carried out. Results of this evaluation will be available as a future guide for determination of the suitability of sediments at proposed dredging sites of the Duwamish River.

Introduction

On September 13, 1974, an electric transformer destined for arctic service was dropped and broken on the north pier of Slip 1 of the Duwamish River. As a result, transformer fluid, 1242 PCB, was discharged onto the pier and into the water. After becoming aware of the type and quantity of fluid spilled, EPA acted to determine the extent of pollution. Once determined feasible, clean up of the fluid was attempted using several hand dredges.

Results of EPA's Region X Laboratory monitoring of the clean-up operation indicate the following:

(1) Only 75 to 90 of an estimated 260 gallons of PCB were removed leaving a large quantity of the material on the river bottom.

(2) The material has begun to spread into and up the river channel at a rate of 2 to 5 ft/day.

Recognizing the seriousness of this problem, DOD and the Army Corps of Engineers will dredge the remaining material using a more conventional dredging procedure. It is EPA Region X laboratory's intent to monitor the project in order to obtain the following information.

(1) Map the extent of PCB pollution before dredging and compare this with similar maps made previously to determine the rate and degree of PCB spreading on the river bottom.

(2) Estimate the amount of PCB removed from the river bottom by determining the amount collected with sediments in on-shore settling ponds.

(3) Using existing methods (Standard Elutriate test and interstitial water test), predict the quantities of deleterious materials (PCB, metals, etc.) released to the water column from the dredge spoil holding ponds.

(4) Compare these estimates (from #3) with that observed to determine the usefulness of known predictive methods.

(5) Determine the amounts of deleterious materials released into river water at the dredge site.

(6) Determine the extent of PCB translocation resulting from the dredge operation.

(7) Estimate the extent of PCB pollution remaining on the river bottom after dredging.

Scope: The program will be carried out in three phases (See Appendix A).

Phase I: (A) A pre-dredge evaluation of sediments will be included to determine the PCB, trace metals, nutrients and oil and grease, etc. burden. The amount of each released into the water using the Standard Elutriate Test and interstitial water test will be studied. In addition, on site monitoring of dredge area water quality parameters such as D.O., conductivity, immediate oxygen demand, pH, temperature and sulfide is proposed. Compositing of samples (when possible) from six areas is planned. An evaluation of the effect of the degree of salinity on the release of various constituents in the Standard Elutriate Test and the interstitial water test will also be made. Because the amount of salt water intrusion varies greatly with the tide and river flow, the degree of salinity near the sediments in the dredged area will not be known. Variation in salinity over 25 ppt per day has been noted. Knowledge of the effect of such a variance on the predictive tests is required for their use.

(B) A river water evaluation program near the dredge site is proposed. The site(s) (to be determined) will be situated such that any plume created by the dredging operation will be observed. Samples of suspended particulate matter (SPM) and whole water will be collected at desired intervals, composited if possible, and analyzed for PCB, trace metals, nutrients, oil and grease, etc. Water quality parameters measurements of D.O., pH, etc. will be made. Thus, background values will be established just before the dredging operation takes place.

Phase II: (A) This will include analysis of holding pond effluent and river water near the dredge site during the dredge operation. Whole water samples of holding pond effluent, composited if possible, will be analyzed for PCB, trace metals, nutrients, etc. On site monitoring of water quality parameters of the holding pond effluent will be made.

(B) Evaluation of river water and SPM near the dredging site for PCB, trace metals, etc. will be made.

Phase III: (A) A post dredge evaluation of sediments will be made. This includes analysis of sediments for PCB, trace metals, etc. and interstitial water test for nutrients. Holding pond sediments will be analyzed for PCB, trace metals, etc.

(B) Evaluation of river water and SPM after dredging for PCB's, trace metals, etc. will be made.

Recommendation

It is our recommendation that EPA personnel and facilities be used to conduct the following:

(1) Collection and analysis of all sediments before and after dredging.

(2) Analysis and evaluation of the Standard Elutriate test and interstitial water monitoring.

(3) Collection and analysis of all effluent from the dredge spoil pond.

(4) Conduct all metal analysis on river water samples collected by Dr. Pavlou.

(5) Collection and analysis of sediments trapped in the dredge spoil pond.

(6) Perform on-site water monitoring of dredge spoil pond effluent.

(7) It is also recommended that Dr. Pavlou's expertise and capabilities be used to:

   (a) Collect river water samples and analyze for nutrients and PCB's (metal, oil and grease and sulfide analysis will be done by EPA personnel)

   (b) Collect suspended particulate matter samples and analyze for PCBs (metal analysis will be done by EPA personnel)

   (c) Perform water monitoring functions on station in river

Monitoring Laboratories

The proposed extensive monitoring program requires the facilities of two laboratories.

(A) EPA's Region X Laboratory

This laboratory has had experience with this problem, as demonstrated by previous PCB mapping and monitoring programs. Also, laboratory expertise in the field of dredging is known. The laboratory recently completed a dredge spoil evaluation study on the upper Duwamish River in which sediments were analyzed and the "Standard Elutriate Test" and "interstitial water monitoring" were performed (See Appendix D) in order to make recommendations as to the extent and type of dredging to be allowed.

(B) Dr. Pavlou U of W Department of Oceanography

Dr. Pavlou's laboratory has experience in the area of PCB sample collection, analysis and data evaluation in ocean and river waters. His laboratory possesses the open water monitoring capability necessary to complete the river water monitoring portion of the study.

Appendix A

Appendix A

Scope: The program will be carried out in three phases. Phase I will include monitoring activities before dredging. Phase II during dredging and phase III after dredging.

I. Phase I (predredge analysis)

A. Sediment evaluation will be made before dredging and used to determine the following:

1. In Sediments

(a) PCB & organochlorine compounds (29 stations)

(b) Metals: Hg, Cd, Pb, Zn, Fe, Mn, Cr, Ni, As and Cu, 6 composite samples in the slip and river channel

(c) Organics: oil and grease, COD, 6 composite samples in the slip and river channel

(d) Sulfide ion, volatile solids, 6 composites in the slip and river channel

(e) Nutrients: P, TKN, TOC, NH_3; 6 composites in the slip and river channel

2. Interstitial Water

(a) PCB and other organochlorine compounds from 6 composite sites

(b) Metals: Hg, Cd, Pb, Zn, Fe, Mn, Cr, Ni, As and Cu from 6 composite sites

(c) Organics: TOC from 6 composite sites

(d) Nutrients: NH_3, NO_3 from 6 composite sites

(e) P, TKN, ~~TOC~~, pH, conductivity, sulfide from 6 composite sites

3. Shake Test with Sediments

(a) PCB from 6 composite sites

(b) Metals: Hg, Cd, Pb, Zn, Fe, Mn, As, Cr, Ni and Cu from 6 composite sites

(c) Organics: TOC, oil and grease from 6 composite sites

(d) Nutrients: P, TKN, TOC, total-N, total-C, NH_3, NO_3 from 6 composite sites

4. On Site Monitoring of Interfacial Water Quality at Time of Sediment Collection

(a) Hydrolab:pH, DO, conductivity, immediate oxygen demand, temperature, E_H and sulfide at each of the stations in or near slip 1 (16 stations total)

(b) Secchi disk reading at each station in or near slip 1 (16 stations)

B. Water Evaluation

Water will be taken to determine the following near the dredging site. This site will be situated such that any plume resulting from the dredge operation will be monitored. The following modes of sample collection will be employed.

(1) Suspended Particulate Matter (SPM)

(a) PCB: 3-1 to 2 hours samplings - 3 samples per day with a blank from an upstream site to be taken at time intervals suggested in IB (2)(a)

(b) If possible, a portion of this filter will be saved for metal determinations

(2) Whole Water

(a) PCB determination of composites based on time and river depth. Top, middle and bottom water samples each taken at one hour intervals in a three hour period be combined (9 total samples/composite) with four periods of collection - one each in the morning, noon and afternoon centered at 7:00 a.m., 1:00 p.m. and 4:00 p.m. with a blank (upstream site) at 10:00 a.m.

(b) Metals determination - separate water samples should be collected to determine Hg, Cd, Pb, Zn, Fe, Mn, As, Cr, Ni, and Cu on 4 composites (see I, B, 2 a)

(c) Nutrients: P, TKN, TOC, NH_3, NO_3 be determined on 4 composites (See I B 2 a)

(d) Oil and grease on 4 samples taken in center of each sampling interval

(e) Sulfide on 4 samples taken in center of each sampling interval

(3) On Site Determinations

(a) Hydrolab - DO, pH, conductivity, temperature, E_H, immediate oxygen demand taken continuously

(b) Secchi disk reading each hour on station

II. Phase II: Analyses During Dredging Operation

This phase deals entirely with monitoring the extent of pollution introduced by the dredging operation. In general, water near the dredge bit and that returning to the river from holding ponds will be monitored.

(A) Holding pond effluent evaluation

(1) Whole Water Analysis

(a) PCB determination on composite samples of effluent from holding ponds will be made. Composites will be made according to time by hand in order to avoid contamination problems with automatic sampling devices. A 300 ml sample taken every 15 minutes is recommended in order to obtain a three-liter sample every 2½ hours, or 3 samples in a 7½ hour dredging period

(b) Metals: Hg, Cd, Pb, Zn, Fe, Mn, As and Cu. Metals samples will be composited using an Isco automatic sampler. Composites will be made according to both time and flow.

(c) Nutrients P, TKN, TOC, NH_3, NO_3, TOC samples will be composited using the Isco samples. (II A 1 b)

(d) Oil and grease - 4 grab samples per day will be taken

(e) Sulfide - 4 grab samples per day will be taken

(f) Suspended solids: hand or auto sample composite will be taken

(2) On Site Monitoring

(a) Hydrolab will be set in place to monitor effluent and/or pond water for pH, conductivity, D.O., sulfide and temperature.

(B) River Water Evaluation Near Dredge Site (See I B)

(1) Suspended Particulate Water

(a) PCB as per (I B 1 (a))

(b) Metals as per (I B 1 (b))

(2) Whole Water Samples

(a) PCB as per (I B 2 (a))

(b) Metals as per (I B 2 (b))

(c) Nutrients as per (I B 2 (c))

(d) Oil and grease as per (I B 2 (d))

(e) Sulfide as per (I B 2 (e))

(3) On Site Determinations

(a) Hydrolab as per (I B 3 (a))

(b) Secchi disk as per (I B 3 (b))

III. Phase III: Post Dredge Evaluation

(A) Evaluation of dredge site and pond sediments will be made to determine the effectiveness of the dredge operation

(1) River bottom sediments. All parameters in I A 1 will be reviewed in the same manner as before.

(2) Interstitial water: all parameters in I A 2 will be reviewed in the same manner as before.

(3) Sediments in pond: A sampling program will be designed to determine the amount of pollutants present in the pond sediments in order to determine the efficiency of pollutant removal from slip 1 by the dredge operation. It is invisioned that 6 composite samples from the pond will be used for this determination:

(a)	PCB	as per (I A 1 (a))
(b)	Metals	as per (I A 1 (b))
(c)	Organics	as per (I A 1 (c))
(d)	Sulfide	as per (I A 1 (d))
(e)	Nutrients	as per (I A 1 (e))

(4) On Site Monitoring

(a) Hydrolab as per (I A 4 a)

(b) Secchi disk as per (I A 4 b)

(B) Water Evaluation - Same as per I B in total will be carried out in order to determine post dredging water quality.

Appendix B

Estimate - Dredge Monitoring Cost

Total Cost * for ALL	Salaries (20,000/yr.)	18,000
	Lab Supplies & Equipment	5,000
	Boat fee (Mon Ark) (10 days)	1,000
	Boat fee (ONAR) (3 days)	3,000
	Total	27,000
Total Cost * for PCB only	Salaries ($25,000)	11,000
	Lab Supplies	3,000
	Boat fee (Mon Ark) (10 days)	1,000
	Boat fee (ONAR)	3,000
	Total	18,000

One day monitoring of Dredge Operation under Phase II (All parameters)	Onar	1,000
	Lab Supplies	1,000
	Salaries	3,000
		5,000
One day monitoring of Dredge Operation under Phase II PCB only	Onar	1,000
	Salaries	1,500
	Lab Supplies	500
		3,000

* Total cost for project assuming a three day work period. If more than three days are required, cost for each additional day of monitoring under phase II must be added

Appendix C

Time Estimate for Dredge Monitoring

For All Work		Man Days
Phase I Part A		84.0
Phase I Part B		21.5
Phase II Part A		17.0
Phase II Part B		21.5
Phase III Part A		65.0
Phase III Part B		21.5
	Total	230.5

For PCB Work Only		
Phase I Part A		41.0
Phase I Part B		11.0
Phase II Part A		3.5
Phase II Part B		11.0
Phase III Part A		32.0
Phase III Part B		11.0
	Total	109.5

Time Estimate For
Phase I Part A
6 Composite Stations
Interstitial Water and Elutriate Test

Determination	Type of Sample Sed.	E.T.	Int.H_2O	BG	Total Samples	Time (Man-Days)
<u>Metals</u>						
Hg	6	6	6	2	20	4
As	6	6	6	2	20	4
8 Metals	6	6	6	2	20	12
<u>Nutrients, Organics & Sulfide</u>						
Total P	6	6	6	2	20	4
NH_3	6	6	6	2	20	4
Total-C (COD)	6	6	6	2	20	1
Total-N (K-N)	6	6	6	2	20	2
NO_3	6	6	6	2	20	2
Oil & Grease	6	6	6	2	20	4
Sulfide	6	6	6	2	20	4
Volatile Solids	6				6	1
TOC	-	6	6	2	14	1
<u>PCB's</u>						
PCB's	6	6	6	2	20	14
PCB's (Survey)	29	-	-	-	29	12
On Site Monitoring (3 men for 5 days)						15
				Total	269	84 Days

Time Estimate For
Phase I Part B - River Water Evaluation

Determination	Type of Sample SPM	H_2O	Total Samples	Time (Man-Days)
Nutrients, Organics & Sulfide				
TOC	-	4	4	0.5
Total P	-	4	4	1
NH_3	-	4	4	1
NO_3	-	4	4	1
Total N (K-N)	-	4	4	0.5
Oil & Grease	-	4	4	1
Sulfide	-	4	4	1
Total C (COD)	-	4	4	0.5
PCB's				
PCB	4	4	8	8
Metals				
Hg	-	4	4	1
As	-	4	4	1
8 Metals	-	4	4	2
On Site Monitoring (3 men X 1 day)				1.5
		Total	52	21.5

Time Estimate For Phase II Part A Holding Pond Effluent
(Estimate for <u>one</u> day dredge operation)

Determination	Type of Sample	Total Samples	Time (Man-Days)
Nutrients, Organics & Sulfide			
Total-C (COD)	3	3	0.5
Total-P	3	3	0.5
NH_3	3	3	0.5
NO_3	3	3	0.5
TOC	3	3	0.5
Total-N (K-N)	3	3	0.5
Oil & Grease	3	3	1
Sulfide	3	3	1
Suspended Solids	3	3	0.5
PCB's			
PCB	3	3	2
Metals			
Hg	3	3	2
As	3	3	2
8 Metals	3	3	4
On Site Monitoring (Hydrolab)			1.5
	Total	39	17

Time Estimate for Phase II Part B - River Water Evaluations

Same as Phase I Part B

Total 21.5 Man-Days

Time Estimate For
Phase III Part A - Post Dredge Evaluation - River Sediments & Dredge Spoils

Determination	Sed.	H_2O	Int. H_2O	BG	Total Sample	Time (Man-Days)
Nutrients, Organics & Sulfide						
TOC	12	-	3	-	15	1.5
*Total P	12	-	3	-	15	2.5
NH_3	12	-	3	-	15	2.5
Total C (COD)	12	-	3	-	15	2.5
Total N (K-N)	12	-	3	-	15	2.5
NO_3	12	-	3	-	15	1.5
Oil & Grease	12	-	3	-	15	2.5
Sulfide	12	-	3	-	15	2.5
Volatile Solids	12	-	-	-	12	1.0
PCB's						
PCB (Survey)	29	-	-	-	29	12
PCB (Spoils)	9 Composites-			-	9	5
Metals						
Hg	12	-	3	-	15	3
As	12	-	3	-	15	3
8 Metals	12	-	3	-	15	8
On Site Monitoring (3 men for 5 days)						15
				Total	215	65

* Includes 6 composites from dredge area and 6 composites from spoil pond

Time Estimate For Phase III Part B - River Water Evaluation - Post Dredge

Same as Phase I Part B

Total 21.5 Man Days

Appendix D

Results of August 12, 1974 Predredge Analysis of Upper Duwamish River Sediments

The following set of tables include results obtained from a previous predredge monitoring operation. The method used to perform calculations and the results for each station are shown. A direct comparison of results obtained using the standard elutriate and interstitial water monitoring tests is given.

[illegible] Results

terstitial Water	Cond.	pH	PCB pg/ml	o-P mg/l	N-NH_3 mg/l	N-NO_3 mg/l	TOC mg/l	C-Total	C-Inorg.	As ug/l	Cd ug/l	Cu ug/l	Fe ug/l	Pb ug/l	Mn ug/l	Hg ug/l	Zn ug/l
010(0)	33,000	7.1	1690	0.10	58	0.14	20	66	46	7.3	70	53	1,870	270	8,200	8.0	83.
011(1)	39,000	7.5	355	0.29	200	0.01	80	284	204	51.0	75	65	33,800	275	10,600	1.2	38.
012(2)	39,000	7.6	741	0.19	2.0	0.01	33	70	37	16.0	75	105	5,750	275	212	3.1	150.
013(4)	40,000	7.7	4000	0.10	3.7	0.02	40	85	45	6.0	73	75	1,830	275	500	3.1	63.
014(5)	40,000	7.7	1825	0.21	59	0.02	80	136	56	19.5	73	73	9,250	275	1,080	4.3	88.

diments	IDOD	PPM	%/ Solids	Total N	G&O. mg/g	ug/g		ug/g	ug/g	ug/g	ug/g	ug/g	ug/g	ug/g
010	83	0.5	80%		0.16	8,000	wet	.8	11.6	18,200	10.0	212		46.
						10,100	dry	1.0	14.6	23,000	12.6	268	.04	58
011	645	0.5	46%		1.04	7,600	wet	1.0	17.4	14,400	18.	200		47
						16,500	dry	2.2	37.8	31,300	39.1	435	.05	102
012	363	0.5	56%		0.49	8,400	wet	1.0	20.0	17,800	18.	172		55
						14,900	dry	1.8	35.5	31,600	32.0	206	.07	98
013	327	0.5	55%		0.67	10,800	wet	1.0	21.6	16,000	24	152		64
						19,700	dry	1.8	39.4	29,300	43.9	278	.09	117
014	330	0.5	50%		1.03	12,000	wet	1.2	27.8	17,600	30.	176		68
						24,000	dry	2.4	55.6	35,200	60.0	352	.09	136

ake Test	pg/ml	Total P mg/l	NH_3 mg/l	N-NO_3 mg/l	TOC mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l	ug/l
010	180	.06	..32	.32	6	3.5	60	688	175	350	2,100	.2	388
011	54	.15	21.	.09	37	10.4	63	99	3,290	310	8,860	.2	59
012	89	.24	4.0	1.0	22	5.3	70	906	656	340	225	.2	250
013	77	.29	8.0	0.10	22	12.5	73	844	719	300	400	.2	188
014	232	.31	13.0	0.14	28	16.5	66	90	875	290	650	.2	50
ceiving H_2O	<20	0.01				0.6	80	100	200	300	40	.1	100

Calculation for

(A) Shake Test

$$\text{Amt. of Poll. Released} = \left[\frac{\text{Conc. of Poll.}}{\text{in g/1000 ml}}\right] (1000\text{ ml}) - (200\text{ ml}) \left[\frac{\text{Sediment Density}}{\text{Density Solid}}\right] \left[\frac{\%\text{ Solids}}{100}\right]$$

from 200 ml Sediment

% Solids on wt basis

(B) Intersitial Water

$$\text{Amt. of Poll. Released} = \left[\begin{matrix}\text{Conc. of Poll.}\\ \text{in g/1000 ml}\end{matrix}\right] (200\text{ ml}) \left[\frac{\text{Sediment Density}}{\text{Density } H_2O\text{ Int.}}\right] \left[\frac{100\text{-}\%\text{-Solids}}{100}\right]$$

from 200 ml Sediment

We assume the Density of Solid in the mixture to be 2.0 to 3.0 (use an average of 2.5)

100-% Solid = % water

FUTURE

Calculation for

(A) Shake Test

$$\begin{array}{l}\text{Amt. of Poll.}\\ \text{Released from}\\ \text{200 ml}\end{array} = \left[\frac{\text{Conc. of Poll.}}{\text{in g/1000 ml}}\right] (1000\ \text{ml}) - (200\ \text{ml}) \qquad \frac{\text{\% Solids Vol}}{100}$$

(B) Interstitial H_2O

$$\begin{array}{l}\text{Amt. of Poll.}\\ \text{Released from}\\ \text{200 ml}\end{array} = \left[\frac{\text{Conc. of Poll.}}{\text{in 1000 ml}}\right] (200\ \text{ml}) \qquad \frac{\text{\% Solids Vol}}{100}$$

definition = % Solids by volume as

$$\%\ \text{Solids}_{\text{vol}} = \frac{\text{Vol Solid}}{\text{Vol Sed.}}\ (\text{cent})$$

where Vol. Solid (cent) = the difference between Vol Sed. and water obtain from Vol Sed. after centrifugation of sediment @ 9 K RPM for 20 minutes.

For Station 0

% Solids = 80%
D sed. $\approx$ 1.4
D Solids $\approx$ 2.5

(A) Shake test

$$\text{Amt. Released in 200 ml} = \left(\frac{\text{Conc.}}{1000\text{ ml}}\right)\left[(1000\text{ ml}) - \left[200\text{ ml}\left(\frac{1.4}{2.5}\right)(.8)\right]\right]$$

$$(X)\quad(1000\text{ ml} - 90\text{ ml})$$

$$= (X)\quad\frac{(910\text{ ml})}{1000\text{ ml}}$$

(B) Int. H_2O

$$\text{Amt. Released in 200 ml} = \left(\frac{\text{Conc.}}{1000\text{ ml}}\right)\left[(200\text{ ml})\left(\frac{1.4\text{ g/ml}}{1.1\text{ g/ml}}\right)\frac{(100 - \%\text{ so}}{100}\right.$$

$$= (X)\quad\frac{200\text{ ml}}{1000\text{ ml}}\left(\frac{1.4\text{ g/ml}}{1.1\text{ g/ml}}\right)(0.2)$$

$$= (X)\quad\frac{51\text{ ml}}{1000\text{ ml}}$$

(C) Sed Amount present

$$= \left(\frac{\text{Conc.}}{\text{g}}\right)(200\text{ ml})\left(\frac{1.4}{\text{ml}}\text{ g}\right)$$

$$= \frac{(X)}{\text{g}} \times (280\text{ g})$$

station O % Solids = 80 D = 1.4

Material	Shake test ug/l	Amt. rel. 200 ml sed.	Int. H_2O ug/l	Amt. rel. 200 ml sed.	Sed. wet wt. ug/g	Total in 200 ml sed.	% material of sed.	% Released by Shake test	% Released by Int. H_2O
As	3.5	3.2 mg	7.3 mg	0.37 mg	8000	2.24 g	0.8%	1.43×10^{-4}%	1.65×10^{-5}%
Cd	60	54.5	70	3.6	0.8	2.24×10^{-4}	8×10^{-5}%	26.8	1.61
Cu	688	625	53	2.7	11.6	3.25×10^{-3}%	1.16×10^{-3}%	19.2	8.3×10^{-2}
Fe	175	159	1870	95.4	18,200	5.1	1.82	3.1×10^{-3}	1.87×10^{-3}
Pb	350	318	270	13.8	10.0	2.8×10^{-3}	1×10^{-3}	11.4	4.94×10^{-1}
Mn	2100	1910	8200	418	212	5.95×10^{-2}	2.12×10^{-2}	3.25	7.04×10^{-1}
Hg	0.2	0.18	8.0	0.4	0.04	1.12×10^{-5}	4×10^{-6}	1.6	3.57
Zn	388	353	83	4.2	46	1.29×10^{-2}	4.6×10^{-3}	2.74	3.25×10^{-2}
PCB*	180	160	1690	86	0.5	1.4×10^{-4}	5×10^{-5}	1.14×10^{-1}	6.15×10^{-2}

* (PCB) given in ng/l

For Station 1

% Solids = 46%
D sed. 1.4
D Solids 2.5

(A) Shake test

$$\text{Amt. Released} = \left[\begin{array}{l}\text{Conc. Poll.}\\ \text{in g/1000 ml}\end{array}\right]\left[(1000\text{ ml}) - (200\text{ ml})\left(\frac{1.4}{2.5}\right)(0.46)\right]$$

$$= \frac{(X)}{1000}\,(1000 - 52\text{ ml})$$

$$= (X)\quad 0.948$$

(B) Int. H_2O

$$\text{Amt. Released} = \left[\begin{array}{l}\text{Conc. Poll.}\\ \text{in g/1000 ml}\end{array}\right]\left[(200\text{ ml})\left(\frac{1.4\text{ g/ml}}{1.1\text{ g/ml}}\right)(.54)\right]$$

$$= \frac{(X)}{1000\text{ ml}}\,(138\text{ ml})$$

$$= (X)\quad (0.138)$$

(C) Sed.

$$\text{Amt. in 200 ml Sed.} = \left(\begin{array}{l}\text{Conc. Poll.}\\ \text{in g/g}\end{array}\right)(200\text{ ml})\left(\frac{1.4\text{ g}}{\text{ml}}\right)$$

$$= (X)\quad 280$$

Station 1 (33011) = Lab # % Solids = 46 Density x 1.4

Material	Shake test ug/l	Amt. rel. 200 ml sed.	Int. H_2O ug/l	Amt. rel. 200 ml sed.	Sed. ug/g	Total in 200 ml sed.	% in Sed.	% Released by Shake test	% Released by Int. H_2O
As	10.4	99 ug	51	7.1 ug	7,600	2.13 g	0.76%	$4.6x10^{-3}$	$3.3x10^{-4}$
Cd	63	60	75	10.3	1.0	$2.8x10^{-4}$	$1x10^{-4}$	21.4	3.7
Cu	99	94	65	8.9	17.4	$4.9x10^{-3}$	$1.7x10^{-3}$	1.9	0.18
Fe	3290	3120	33,800	4,670	14,400	4.03	1.44	0.08	0.17
Pb	310	294	275	38	18	$5x10^{-3}$	$1.8x10^{-3}$	5.9	0.76
Mn	8860	8400	10,600	1,462	200	$5.6x10^{-2}$	$2x10^{-2}$	15	2.6
Hg	0.2	0.19	1.2	0.17	0.05	$1.4x10^{-5}$	$5x10^{-6}$	1.36	1.21
Zn	59	56	38	5.2	47	$1.3x10^{-2}$	$4.7x10^{-3}$	0.43	0.04
PCB *	54	51	355	49	0.5	$1.4x10^{-4}$	$5x10^{-5}$	0.036	0.035

* (PCB) given in ng/l

For Station 2

% Solids = 56.2%
D sed. = 1.4
D Solids 2.5

(A) Shake test

$$\text{Amt. Released} = \left[\begin{matrix}\text{Conc. Poll.}\\ \text{in g/1000 ml}\end{matrix}\right]\left[(1000\ \text{ml}) - (200\ \text{ml})\left(\frac{1.4}{2.5}\right)(.56)\right]$$

$$= (X) \quad (1000 - 63)/1000$$

$$= (X) \quad 0.937$$

(B) Int. H_2O

$$\text{Amt. Released in 200 ml} = \left(\begin{matrix}\text{Conc. Poll}\\ \text{in g/1000 ml}\end{matrix}\right)(2000\ \text{ml})\left(\frac{1.4}{1.1}\right)(.438)$$

$$= (X) \quad 0.113$$

(C) Sed.

$$\text{Amt. Poll. Pres. in 200 ml Sed.} = \left(\begin{matrix}\text{Conc. Poll.}\\ \text{in g/g}\end{matrix}\right)(200\ \text{ml})(1.4)$$

$$= (X) \quad 280$$

Station 2 (33012) = Lab # % Solids = 56 Density 1.4

Material	Shake test ug/l	Amt. rel. 200 ml sed.	Int. H_2O ug/l	Amt. rel. 200 ml sed.	Sed. ug/g	Total in 200 ml sed.	% in Sed.	% Released by Shake test	% Released by Int. H_2O
As	5.3	5.0	16.0	1.8	8,400	2.35 g	$8x10^{-1}$	$2.1x10^{-4}$ %	$7.6x10^{-5}$
Cd	70	65.6	75	8.5	1.0	$2.8\ x10^{-4}$	$1x10^{-4}$	23.4	3.03
Cu	906	850	105	11.9	20.0	$5.6\ x10^{-3}$	$2x10^{-3}$	15.1	0.21
Fe	656	615	5750	650	17,800	4.98	1.78	$1.23x10^{-2}$	$1.30x10^{-2}$
Pb	340	319	275	31	18	$5.05x10^{-3}$	$1.8\ x10^{-3}$	6.31	$6.15x10^{-1}$
Mn	225	211	212	24	172	$4.82x10^{-2}$	$1.72x10^{-2}$	$4.37x10^{-2}$	$5x10^{-2}$
Hg	0.2	0.19	3.1	0.35	0.07	$1.96x10^{-5}$	$7x10^{-6}$	$9.8\ x10^{-1}$	1.79
Zn	250	235	150	16.9	55	$1.54x10^{-2}$	$5.5\ x10^{-3}$	1.52	$1.1\ x10^{-1}$
PCB*	89	83.5	741	83.6	0.5	$1.4\ x10^{-4}$	$5x10^{-5}$	$5.95x10^{-2}$	$5.95x10^{-2}$

* (PCB) given in ng/l

Station 4

(A) Shake test

$$\text{Amt. Released (Poll.) for 200 ml Sed.} = \left(\begin{array}{l}\text{Conc Poll.}\\ \text{in g/1000 ml}\end{array}\right)\left[(1000 - (200)\left(\frac{1.4}{2.5}\right)(0.55))\right]$$

$$= \frac{(X)}{1000}\ (1000 - 62)$$

$$= (X)\ 0.938$$

(B) Int. H_2O

$$\text{Amt. Poll. Released for 200 ml Sed.} = \left(\begin{array}{l}\text{Conc. Poll.}\\ \text{in g/1000 ml}\end{array}\right)\ (200)\left(\frac{1.4}{1.1}\right)(0.45)$$

$$= (X)\ 0.114$$

(C) Sed.

$$\text{Amt. Poll. pres. 200 ml sed.} = \left(\text{Conc Poll } \gamma/g\right)\ (200\text{ ml})(1.4)(X)$$

$$= (X)\ 280$$

Station 4 (33013) = Lab # % Solids = 54.5 Density (sed = 1.4)

Material	Shake test ug/l	Amt. rel. 200 ml sed.	Int. H_2O ug/l	Amt. rel. 200 ml sed.	Sed. ug/g	Total in 200 ml sed.	% in Sed.	% Released by Shake test	% Released by Int. H_2O
As	12.5	11.8	6.0	0.7	10,800	3.03 g	1.08	3.9×10^{-4}	2.3×10^{-5}
Cd	73	68.5	73	8.3	1.0	2.8×10^{-4}	1×10^{-4}	24.4	2.96
Cu	844	793	75	8.6	21.6	6.06×10^{-3}	2.16×10^{-3}	36.7	3.98×10^{-1}
Fe	719	676	1830	209	16,000	4.48	1.6	1.51×10^{-2}	4.67×10^{-3}
Pb	300	282	275	31.4	24	6.72×10^{-3}	2.4×10^{-3}	4.2	4.68×10^{-1}
Mn	400	376	500	57	152	4.26×10^{-2}	1.52×10^{-2}	8.85×10^{-1}	1.34×10^{-2}
Hg	0.2	0.19	3.1	0.35	0.09	2.52×10^{-5}	9×10^{-6}	7.5×10^{-1}	1.39
Zn	188	177	63	7.2	64	1.79×10^{-2}	6.4×10^{-3}	9.9×10^{-1}	4.02×10^{-2}
PCB *	77	72.4	4000	460	0.5	1.4×10^{-4}	5×10^{-5}	5.14×10^{-2}	3.3×10^{-1}

* (PCB) given in ng/l

Station 5

(A) Shake test

Amt. Poll. Released from 200 ml Sed. $= \left(\begin{matrix}\text{Conc. Poll.}\\ \text{g/1000 ml}\end{matrix}\right) \left[\left(1000\text{ ml} - (200\text{ ml})\right)\left(\frac{1.4}{2.5}\right)(.5)\right]$

$= (X) \quad (1000 - 56)/1000$

$= (X) \quad .944$

(B) Int. H_2O

Amt. of Poll. Released from 200 ml Sed. $= \left(\begin{matrix}\text{Conc. Poll.}\\ \text{g/1000 ml}\end{matrix}\right) \quad (200\text{ ml})\left(\frac{1.4}{1.1}\right)(.5)$

$= (X) \quad .127$

(C) Sed.

Total amt. of poll. present $= \left(\begin{matrix}\text{Conc. Poll.}\\ \text{g/g}\end{matrix}\right) \quad (200\text{ ml})(1.4)$

$(X) \quad 280$

Station 5 (33014) = Lab # % Solids = 50% Density Sed 1.4

Material	Shake test ug/l	Amt. rel. 200 ml sed.	Int. H_2O ug/l	Amt. rel. 200 mlsed.	Sed. ug/g	Total in 200 ml sed.	% in Sed.	% Released by Shake test	% Released by Int. H_2O
As	16.5	15.6	19.5	2.5	13,000	3.36	1.2	4.65×10^{-4}	7.5×10^{-5}
Cd	66	62.5	73	9.3	1.2	3.36×10^{-4}	1.2×10^{-4}	18.7	2.76
Cu	90	85	73	9.3	27.8	7.78×10^{-3}	2.78×10^{-3}	1.09	1.19×10^{-1}
Fe	875	827	9250	1170	17,600	4.92	1.76	1.68×10^{-2}	2.38×10^{-2}
Pb	290	274	275	349	30	8.4×10^{-3}	3×10^{-3}	3.26	4.16
Mn	650	614	1080	137	176	4.92×10^{-2}	1.76×10^{-2}	1.24	2.78×10^{-1}
Hg	0.2	0.19	4.3	0.5	0.09	2.52×10^{-5}	9×10^{-6}	7.56×10^{-1}	1.98
Zn	50	47.3	88	11.2	68	1.91×10^{-2}	6.8×10^{-3}	2.48×10^{-1}	5.9×10^{-2}
PCB*	232	219	1825	232	0.5	1.4×10^{-4}	5×10^{-5}	1.56×10^{-1}	1.66×10^{-1}

* (PCB) given in ng/l